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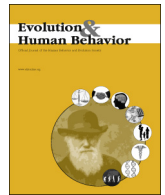
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## Original Article

Are smiles a sign of happiness? Spontaneous expressions of judo winners<sup>☆</sup>Carlos Crivelli, Pilar Carrera, José-Miguel Fernández-Dols<sup>\*</sup>

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## ABSTRACT

Which is the strongest predictor of Duchenne smiles? Is it emotion or sociality? Two field studies on the production of facial behavior by winning judo fighters ( $N = 174$ ) are presented, testing if judo fighters smiled while being happy or while they were engaged in social interaction with the audience. Our studies simultaneously meet important methodological requirements: intense emotions; precise moment-to-moment coding of facial expressions; behavioral records long enough to allow smiles to unfold; discrimination between records of interactive and non-interactive behavior, and self-reports of emotional experience after winning a medal. We found that Duchenne smiles were not a necessary sign of happiness. Although all the judo fighters won their respective matches, they displayed a very low proportion of Duchenne smiles (.15 in Study 1, and .21 in Study 2). Being engaged in social interaction (communicative gestures with arms and hands while facing the audience) was found to be the strongest predictor for the occurrence of Duchenne smiles. Our studies provide support for the view that facial expressions are tools for social interaction (Behavioral Ecology Theory), rather than read-outs of basic emotions (Facial Expression Program).

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## 1. Introduction

When does a person smile? An answer to this question is needed to decide between two accounts of facial expression of *emotion*. According to Facial Expression Program (FEP, Ekman, 1972; Izard, 1971; see Russell & Fernández-Dols, 1997), smiles – specifically Duchenne smiles – are produced when the person is happy. Conversely, according to Behavioral Ecology Theory (BET, Fridlund, 1994), smiles, including Duchenne smiles, are tools the person uses during social interaction. Thus, according to FEP, a smile has a fixed emotional meaning, whereas according to BET, smiles can mean different things in different contexts, such as a greeting, solidarity, reassurance, embarrassment, and so on. The specific prediction that differentiates the two theories is that FEP predicts the occurrence of Duchenne smiles when the person is happy, regardless of the situation's sociality (Ekman, 2003). On the other hand, BET predicts that the likelihood of a Duchenne smile varies with the sociality of the situation, even when a person is happy (Fridlund, 1991). From the signaler's point of view, the production of a signal that has the potential to convey highly specific information is independent from the underlying mechanism that produced it (e.g., an affective state). Thus, whereas FEP assumes that facial expressions are indexes of basic emotion, BET considers that facial expressions

and emotions are not necessarily related; knowing that the production of a signal is due to some affective mechanism does not inform us on its potential to serve as a referential signal (Seyfarth & Cheney, 2003).

## 1.1. The ethological approach to the social and emotional messages of smiling

A landmark in the study of the social and emotional causes of smiling is Kraut and Johnston's (1979) pioneering naturalistic observation of bowlers making a strike, ice hockey fans cheering their team, and pedestrians on a sunny day. The probability of detecting a smile during interactive times was significantly higher than during non-interactive times (.42 vs. .04 for bowlers, .27 vs. .12 for ice hockey fans, and .62 vs. .12 for pedestrians). In their conclusion, Kraut and Johnston emphasized that an ethological approach would help in the study of not only the causes but also the effects of facial expression on subsequent social interaction. Despite the importance of studying human facial displays through a careful description of spontaneous facial behavior, Kraut and Johnston's work was mainly ignored by mainstream research on facial expression. Observational approaches to facial behavior have been practically non-existent for decades (Fernández-Dols & Crivelli, 2013). Even experimental studies on the actual production of facial expression have been rare compared to the large amount of paper-and-pencil recognition studies (Reisenzein, Studtmann, & Horstmann, 2013).

Fridlund's (1994) approach to facial expression in the framework of BET revived Kraut and Johnston's proposal. Fernández-Dols and Ruiz-Belda (1995) followed Kraut and Johnston's ethological approach by observing Olympic Games gold-medalists during the awards ceremony. Olympic gold-medalists on the podium smiled up to 76% of the

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time during the interactive periods (i.e., when receiving the medals from the authorities, when greeting the spectators), but only 10% and 3% of the time when waiting behind the podium and listening to the national anthem—i.e., during non-interactive periods. Fernández-Dols and Ruiz-Belda improved upon Kraut and Johnston's method by obtaining retrospective emotional reports from a sub-sample of gold-medalists. Reports of happiness across the ceremony were similar during the interactive and the non-interactive periods, which strongly suggest that smiles are not necessarily present when happiness occurs. In the same vein, Ruiz-Belda, Fernández-Dols, Carrera, and Barchard (2003) recorded facial expressions of bowlers after scoring a strike and soccer fans when their team scored. They found that, for the interactive records, the mean probability of a smile for bowlers and soccer fans was .78 and .70 respectively, whereas it decreased significantly to .09 and .07 when observing non-interactive records. All in all, these studies supported a BET interpretation of smiles. On this view, smiles are flexible, adaptive tools displayed within strategic social games aimed at obtaining some physical or psychological resources (Fridlund, 1994).

Matsumoto and Willingham (2006; for a replication with blind judo fighters, see Matsumoto & Willingham, 2009) challenged these previous findings in a field study in which they analyzed 190 out of 2735 photographs of judo fighters taken by a professional photographer during the Athens Olympic Games. The authors reported that 29 out of 40 judo fighters displayed Duchenne smiles after winning a gold- or bronze-medal match. Matsumoto and Willingham concluded that sociality was not a variable related to the display of smiles, and previous findings supporting a link between smiling and social interaction (Fernández-Dols & Ruiz-Belda, 1995; Kraut & Johnston, 1979; Ruiz-Belda et al., 2003) were actually *nonfindings* because of methodological flaws. Matsumoto and Willingham (2006, p. 576) wrote:

*"[Our] results contrast to the findings of previous field studies reporting nonfindings (Fernández-Dols & Ruiz-Belda, 1995; Kraut & Johnston, 1979; Ruiz-Belda et al., 2003). We contend that the methodology we used corrected methodological limitations of the previous studies. (...) Some may argue that the expressions were produced because the athletes were in a social situation. (...) We argue, however, that these factors probably did not affect the very first expressions displayed at match completion (which are the ones we analyzed) (Matsumoto & Willingham, 2006, p. 576)."*

Matsumoto and Willingham's (2006) requirements for overcoming the limitations of previous field studies were (a) the use of intense emotions (i.e., emotions not produced in the middle of a task but on the final outcome), (b) a precise moment-to-moment measurement of the expressions, (c) discrimination between Duchenne and non-Duchenne smiles, and (d) the analysis of interactive and non-interactive behavioral records long enough to allow smiles to unfold. To these four requirements an obvious fifth can be added for a flawless test of the predictive weight of happiness and social interaction in the display of smiles: (e) an explicit discrimination between records of interactive and non-interactive behavior. Unfortunately, Matsumoto and Willingham's requirements have never been simultaneously accomplished by the published studies to date—including Matsumoto and Willingham's field studies (2006, 2009).

Requirement (a) was unfulfilled in the studies with happy bowlers, and – to some extent – to hockey and soccer fans' studies (Kraut & Johnston, 1979; Ruiz-Belda et al., 2003), but it was fulfilled in Fernández-Dols and Ruiz-Belda's (1995) study with gold medalists. Requirement (b) was unaccomplished by Kraut and Johnston's study, which was carried out in 1979 – when video recordings were unusual – but it was also ignored by Matsumoto and Willingham (2006, 2009), who based their findings on an unsystematic sample of still photographs taken by a sports photographer. Requirement (c) was unaccomplished by Kraut and Johnston (1979), who carried out their studies when researchers did not contemplated the theoretical distinction between

Duchenne smile and other kinds of smiles (see Ekman, Friesen, & Ancoli, 1980), and also by Matsumoto and Willingham (2006, 2009; in which the use of still photographs makes the checking of this requirement uncertain), but it was fulfilled by Fernández-Dols and Ruiz-Belda (1995), and Ruiz-Belda et al. (2003). Requirement (d) was not fully carried out by Ruiz-Belda et al. (2003) or maybe by Kraut and Johnston (1979), but the two non-interactive periods of the awards ceremony studied by Fernández-Dols and Ruiz-Belda (1995) had an average length of 18 and 22.6 s, representing plenty of time for the unfolding of smiles. Finally, requirement (e) was not considered in Matsumoto and Willingham (2006, 2009) due to the absence of an explicit differentiation between interactive and non-interactive periods, but it was fulfilled by Kraut and Johnston (1979), Fernández-Dols and Ruiz-Belda (1995), and Ruiz-Belda et al. (2003).

## 1.2. The present research

The studies reported are new tests of the predictive weight of happiness and social interaction when displaying Duchenne smiles. For comparison purposes, they are also focused on judo fighters and will fulfill the above-mentioned requirements.

### 1.2.1. Intense emotions

Study 1 data were obtained in one of the most important moments in the career of any young judo fighter: the victory in a junior national championship match. In order to check the intensity of judo fighters' emotional experience, we obtained – immediately after match completion – self-reports on a sample of gold and bronze medalists. In Study 2, we analyzed the expressions of judo fighters who performed *ippons*<sup>1</sup> – instant wins – in important international competitions. Instant wins constitute a powerful antecedent for eliciting intense happiness in these agonistic contexts.

### 1.2.2. Moment-to-moment measurement of facial expressions

In a complex setting like judo competitions, registering a clear and visible face in every single observation is not always possible. For this reason, an assessment of when judges were able to observe clear faces was needed. We divided behavioral records into different time intervals. This allowed us not only to show the distributions of frequencies related to different time intervals in which facial expressions were analyzed, but also the possibility of detecting outliers. Time intervals were previously selected as video frames, and then they were transformed into seconds. The first interval comprised of a very short and initial interval of only 10 frames (from second zero to 0.40 s). The second interval ranged from 0.44 to 2 s, whereas the third interval ranged from 2.04 to 4 s. With the first three intervals, we covered the generally accepted 4 s time span for facial expressions to unfold after the eliciting circumstance (Ekman, 2003; cf. Matsumoto & Willingham, 2006). An additional time interval was selected from 4.04 s until the end of each study's behavioral record (from 4.04 to 7 s in Study 1 and from 4.04 to 5 s in Study 2).

### 1.2.3. Discrimination between Duchenne and non-Duchenne smiles

The Facial Action Coding System (FACS, Ekman & Friesen, 1978) allows researchers to analyze facial muscle contractions (called "action units"). For every behavioral record, two independent FACS-certified judges systematically assessed action units in a frame-to-frame fashion. Coders' analyses were restricted to facial displays occurring

<sup>1</sup> An *ippon* provides an instant win when any of the next criteria are met (International Judo Federation, 2011): (a) throwing the opponent with control on his back with considerable force and speed, (b) holding the opponent while having his back, and at least one shoulder, in contact with the tatami for 25 s, (c) when the opponent gives up the fight (i.e., due to suffering an armlock or a strangling technique), or (d) when the opponent loses consciousness in strangling techniques and locks.

when the timecode was superimposed on the screen. Coders used Final Cut Pro 7 canvas on a 13-inch screen, viewing every behavioral record frame by frame in high quality and resolution (Apple ProRes 422). The working format for each video was DV PAL, with a rate of 25 frames per second.

#### 1.2.4. Behavioral records long enough to allow smiles to unfold

Only behavioral records that lasted at least the fixed observational time frame for each study – 7 and 5 s respectively after match completion – were included on behalf of the argument that expressions needed a critical 4-s window to unfold (Ekman, 2003). Response latency was measured from match completion until the first action unit clearly appeared for coding.

#### 1.2.5. Discrimination between interactive and non-interactive times

Judo competitions take place in social contexts where the audience is always present. Judo matches usually last 5 min, although referees interrupt them continually in order to formally restart the match (e.g., when a judo fighter is out of bounds). In this social setting, a conservative approach to the definition of social interaction was necessary, which increased the probability of smiles during supposedly non-interactive times. Due to the social nature of judo competitions, as well as the impossibility of controlling the direction of gazes, social interaction was defined exclusively as explicit communicative gestures made with the arms and hands linked with verbal messages while the fighter was facing the audience (e.g., conventional greetings, deictics, emblems of triumph; see Ekman & Friesen, 1969).

## 2. Study 1: Spanish judo fighters

We video recorded and analyzed judo fighters' facial expressions at the 2010 Under-23 Spanish National Judo Championship.

### 2.1. Methods

#### 2.1.1. Participants

Sixty-five judo matches were video recorded. We excluded 4 cases due to lack of visibility for coding during the observational time frame, 2 cases that lasted less than the fixed observational time frame, and 4 cases that ended up due to injuries or penalizations. The final sample consisted of 55 judo fighters (43 males, 22 females) who won their matches (13 gold-medal, 13 bronze-medal, and 29 preliminary round matches).

#### 2.1.2. Equipment

For video recording judo matches, we used two Panasonic HDC-SD60 video cameras with codec AVCHD, 1080/50i signal system, and 35x i.Zoom. Video editing with Final Cut Pro and Motion 4 provided an accurate selection of a 7 s time code appearing at the beginning of the observational time frame, and making it disappear from the screen when the time frame for observation ended. By using this editing, we were able to run the whole length of every behavioral record, coding action units from the moment in which the time code was superimposed on the screen until it disappeared.

#### 2.1.3. Procedure

When recording judo matches, camera operators were placed on one side of the tatami (between the coaches' seats, and before teams' warm-up area and spectators' main stands). Between 2 and 30 min after the final matches ended, and before the award ceremony and doping control took place, a sample of 20 judo fighters winning a gold or bronze medal (10 male and 10 female) volunteered to fill out 16 8-point Likert scales (from 0 = not at all to 7 = very much) on their emotional experience at moment in which the match ended because of their victory (*angry, disappointed, disgusted, euphoric, fearful, frustrated, guilty, happy, proud, sad, shameful, surprise, pleasure, displeasure, aroused*, and

*relaxed*). They were debriefed after completing the questionnaire. For all behavioral records, the precise video frame within the observational time frame of 7 s in which the first action unit or combination of them occurred was transformed into seconds when multiplying frames by 0.04 (25 video frames per second).

#### 2.1.4. Coding of facial expressions

Two independent FACS-certified judges coded all the action units of judo fighters winning a match during a 7-s time frame. Inter-rater reliability for all action units' coding was computed using Cohen's (1960) kappa coefficient ( $Kappa = .88$ ). In cases of discrepancies between the two judges, a third independent certified FACS coder decided for a resolution. For Duchenne smiles, discrepancies were only found between the two judges in one case (inter-rater reliability for Duchenne smiles' coding,  $Kappa = .92$ ). All of the 55 judo fighters' videos included some coded action units within the observational time frame, thus allowing measures of time response latency from match completion. For social interaction assessment, two independent judges sequentially viewed every behavioral record while verifying if gestures while facing the audience appeared before, at the same time, or after the occurrence of Duchenne smiles (inter-rater reliability for social interaction's assessment,  $Kappa = .92$ ). There was no discrepancy for behavioral records in which Duchenne smiles occurred when observing social interaction.

### 2.2. Results

#### 2.2.1. How often did winning judo fighters smile?

Although 13 out of 55 judo fighters smiled when winning a match, only 8 displayed Duchenne smiles (Table 1). For rejecting the null hypothesis in a right unilateral binomial test with chance level set at .50 and  $\alpha = .01$ , the occurrence of at least 37 Duchenne smiles was needed (binomial test:  $z = 2.56, p = .005$ ). Duchenne smiles were displayed by judo fighters winning a gold (4 out of 13), or bronze medal (3 out of 13), as well as during preliminary round matches (1 out of 29). Considering only judo fighters winning a gold medal, the proportion of Duchenne smiles' occurrences was still very low (.31). Opened mouths (AU26; 46 out of 55 observations) and heads down (AU54; 34 out of 55 observations) were the action units most frequently displayed when winning a judo match.

#### 2.2.2. Facial expression of emotion or social interaction?

Judo fighters winning a gold or bronze medal displayed significantly more Duchenne smiles than judo fighters winning a preliminary round match; Pearson chi-square:  $\chi^2(1; N = 55) = 6.08, p = .014, \Phi = .33$ . Likewise, when taking into account social interaction, judo fighters winning a match displayed significantly more Duchenne smiles when they were engaged in social interaction than when they were not engaged in social interaction; Pearson chi-square:  $\chi^2(1; N = 55) = 6.73, p = .009, \Phi = .35$ . Although both variables – winning a medal and social interaction – were significantly related to the occurrence of Duchenne smiles, all Duchenne smiles were produced during social interaction episodes (see Table 1).

#### 2.2.3. Response latency and face availability

Response latency expected values were similar to Ruiz-Belda et al.'s (2003) findings. It was also compatible with a 4-s time frame for expressions to unfold after the eliciting antecedent (Ekman, 2003). We found that 44 out of 55 observations were located within that range. The response latency for the first action unit being coded ( $M \pm SE = 2.39 \pm .26$ ) was positively skewed (skewness  $\pm SE = .64 \pm .32$ ). We relied on robust estimators (Andrews' Wave = 2.12), avoiding the overestimation of our measures of central tendency (Wilcox & Keselman, 2003). In any case, the expected values for response latency were below 2.5 s. Specifically, with respect to Duchenne smiles ( $M \pm SE = 2.54 \pm .86$ ; Andrews' Wave = 1.49), we can conclude that 2.5 s is time enough for Duchenne smiles to unfold, taking into account that



**Table 1**  
Action units (AUs), and Duchenne smile's frequencies and percentages as a function of social interaction after match completion.

Action Unit	Study 1			Study 2		
	Social interaction			Social interaction		
	Yes (n = 32)	No (n = 23)	Total (N = 55)	Yes (n = 79)	No (n = 40)	Total (N = 119)
AU1. Inner brow raise	11 (34.4)	3 (13)	14 (25.5)	13 (16.5)	5 (12.5)	18 (15.1)
AU2. Outer brow raise	9 (28.1)	3 (13)	12 (21.8)	13 (16.5)	5 (12.5)	18 (15.1)
AU4. Brow lowerer	6 (18.8)	2 (8.7)	8 (14.5)	10 (12.7)	1 (2.5)	11 (9.2)
AU6. Cheek raise	9 (28.1)	–	9 (16.4)	24 (30.4)	4 (10)	28 (23.5)
AU10. Upper lip raiser	2 (6.3)	3 (13)	5 (9.1)	9 (11.4)	4 (10)	13 (10.9)
AU12. Lip corner puller	9 (28.1)	4 (17.4)	13 (23.6)	37 (46.8)	4 (10)	41 (34.5)
AU14. Dimpler	–	–	–	1 (1.3)	5 (12.5)	6 (5)
AU17. Chin raiser	–	–	–	3 (3.8)	3 (7.5)	6 (5)
AU20. Lip stretch	3 (9.4)	–	3 (5.5)	–	–	–
AU22. Lip funneler	6 (18.8)	1 (4.3)	7 (12.7)	12 (15.2)	2 (5)	14 (11.8)
AU24. Lip presser	2 (6.3)	1 (4.3)	3 (5.5)	–	–	–
AU25. Lips part	13 (40.6)	7 (30.4)	20 (36.4)	21 (26.6)	8 (20)	29 (24.4)
AU26. Jaw drop	27 (84.4)**	19 (82.6)**	46 (83.6)**	66 (83.5)**	27 (67.5)*	93 (78.2)**
AU27. Mouth stretch	3 (9.4)	1 (4.3)	4 (7.3)	25 (31.6)	1 (2.5)	26 (21.8)
AU28. Lips suck	–	–	–	3 (3.8)	3 (7.5)	6 (5)
AU43. Closed eyes	6 (18.8)	2 (8.7)	8 (14.5)	8 (10.1)	1 (2.5)	9 (7.6)
AU53. Head up	4 (12.5)	–	4 (7.3)	16 (20.3)	4 (10)	20 (16.8)
AU54. Head down	18 (56.3)	16 (69.6)*	34 (61.8)*	32 (40.5)	28 (70)**	60 (50.4)
AU6 & AU12. Duchenne smile	8 (25)	–	8 (14.5)	23 (29.1)	2 (5)	25 (21)

Note. Only AUs with a total occurrence higher than 5% are taken into account. Percentages inside parentheses. Duchenne smiles = the convergent contraction of *zygomatic major* and *orbicularis oculi-pars lateralis* facial muscles. Study 1 = seven seconds of observation after match completion. Study 2 = five seconds of observation after match completion.

\*  $p < .05$  and \*\*  $p < .01$  for right unilateral binomial tests with chance level set conservatively at .50.

there was only one outlier (a Duchenne smile was observed 6.8 s after match completion, although the face was not visible during the first 4 s of observation).

#### 2.2.4. Reports of subjective experience

We cannot conclude that – when winning a medal – intensity ratings of the emotional experience self-reports made by judo fighters displaying Duchenne smiles differed significantly from those made by judo fighters not displaying Duchenne smiles. Mann–Whitney  $U$  tests:  $N = 20$ , all  $U$ s  $> 21$ . *Happy* ratings of winning judo fighters who displayed Duchenne smiles ( $M \pm SE = 6.33 \pm .67$ ) did not differ significantly from winning judo fighters' *happy* ratings when not showing Duchenne smiles ( $M \pm SE = 5.29 \pm .50$ ),  $p = .082$ ,  $r = -0.39$ . Likewise, ratings for *euphoric* ( $M \pm SE = 4 \pm 1.16$ ;  $M \pm SE = 2.43 \pm .56$ ), *proud* ( $M \pm SE = 3.67 \pm .96$ ;  $M \pm SE = 4 \pm .70$ ), *pleasure* ( $M \pm SE = 6.17 \pm .48$ ;  $M \pm SE = 5.21 \pm .33$ ), *arousal* ( $M \pm SE = 5.5 \pm .56$ ;  $M \pm SE = 5.14 \pm .25$ ), and *relaxed* ( $M \pm SE = 3.17 \pm 1.11$ ;  $M \pm SE = 2.71 \pm .47$ ) did not differ significantly between judo fighters displaying Duchenne smiles and those who did not, all  $ps > .13$ . Mean ratings for the indexes measuring an *angry*, *disappointed*, *disgusted*, *fearful*, *frustrated*, *guilty*, *sad*, *shameful*, *surprised*, and *displeasure* subjective experience were equal or lower than 1. Although a small sample size ( $N = 20$ ) enhances the likelihood of making a Type II error, a close inspection of the estimated mean difference and its corresponding 95% confidence interval (Fig. 1) shows that the overlap and average margin of error ratio (.90) are big enough to support our conclusions (Cumming & Finch, 2005).

### 3. Study 2: international judo fighters

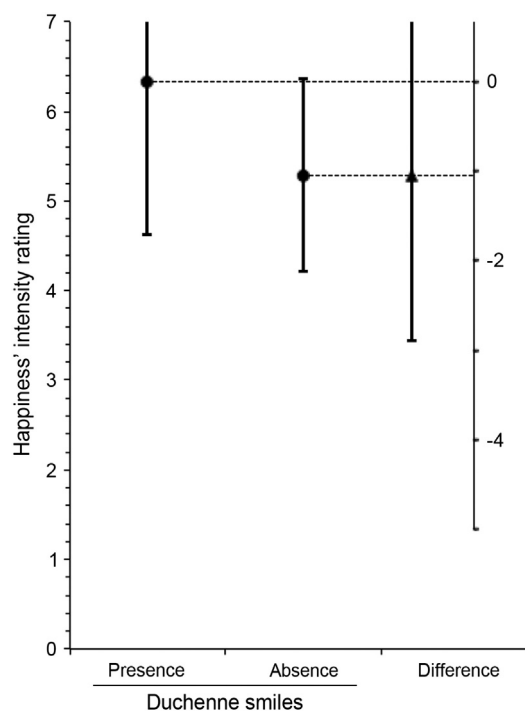
In Study 1 we found that judo fighters winning a match displayed a very low proportion of Duchenne smiles, and that they all occurred when judo fighters were engaged in social interaction. The presence or absence of Duchenne smiles did not predict significant differences in the intensity of emotional experience self-reported by judo fighters who won a gold or bronze medal. An additional finding was that the first facial expressions were displayed on average within a 2.5 s range after match completion. Study 2 was aimed at replicating these findings through a broader and more culturally diverse sample than that of

Study 1. Subjects included a large sample of judo fighters – junior and senior – participating in different international events over a decade.

#### 3.1. Methods

##### 3.1.1. Participants

From an initial sample of 202 international judo matches (2 DVDs containing 101 *ippons* each), a final sample of 119 judo fighters winning a match (28 females, 91 males) was analyzed after discarding



**Fig. 1.** Means with 95% confidence intervals (CIs) for judo fighters winning a medal as a function of displaying or not Duchenne smiles at match completion. Mean difference =  $-1.05$ , 95% CI  $[-2.89, 0.80]$ .

behavioral records that did not include visible faces or the minimal observational time frame (5 s). Judo fighters were from 29 different countries and judo matches were hosted in 15 different countries (11 in Europe, 2 in Asia, and 2 in America). Fifty-eight judo fighters were recorded during judo competitions taking place between 1999 and 2002, and 61 between 2006 and 2008. Fifty-two observations contained judo fighters competing for a medal (36 gold finals, and 16 bronze finals), and 67 were of preliminary round matches.

### 3.1.2. Procedure

Judo matches were recorded by Fighting Films ([www.fightingfilms.com](http://www.fightingfilms.com)), a company specialized in commercial videos of judo fighters competing in junior and senior international events (e.g., Kano Cup, World Cups, junior and senior World Championships). These video recordings – a popular series of judo videos for practitioners and martial arts supporters – have high image quality and resolution, containing replays from different angles and slow motion cameras for some matches, as well as information regarding judo fighters' nationality, country hosting the event, fighting category, and if the match is related to a bronze or gold medal final, or any other preliminary matches. We randomly selected two DVDs containing a total of 202 judo matches from the series *101 Judo Ippons* (Fighting Films, 2003, 2009). Judo matches may end in many ways, but *ippon* is the way judo fighters would prefer to end a match. By discarding other endings in which judo fighters could anticipate their outcome (e.g., winning by points when running the clock), our study reduced measurement errors by establishing a clear-cut beginning of the observational time frame. Two independent judges coded the occurrence of all action units and the precise video frame in which the first action unit or combination of them occurred. The procedure was identical to that of Study 1 except that this time the observational time frame was 5 s.

### 3.1.3. Coding of facial expressions

Two independent FACS-certified judges coded action units of judo fighters winning a match during a 5-s time frame. Inter-rater reliability was computed using Cohen's (1960) kappa coefficient (FACS coders' inter-rater reliability, Kappa = .89; social interaction's assessment inter-rater reliability, Kappa = .91). There were no discrepancies between judges when coding Duchenne smiles or when assessing social interaction when a Duchenne smile occurred. Except for a neutral case in which no action units were coded, action units' response latency measures were computed for all observations.

## 3.2. Results

### 3.2.1. How often did winning judo fighters smile?

Although 41 judo fighters out of 119 smiled, only 25 of them displayed Duchenne smiles; left unilateral binomial test:  $\pi = .50$ ,  $z = -6.33$ ,  $p < .001$ . Only 13 gold-medalists out of 36, 4 bronze-medalists out of 16, and 8 preliminary round winners out of 67 judo fighters displayed Duchenne smiles after winning a judo match. Even if only judo fighters winning a gold medal are taken into account, the

proportion of Duchenne smiles' occurrences was still very low (.36). Smiling (AU 12) was displayed in a low proportion of cases (.35), whereas opened mouths (AU 26, 93 out of 119 observations) and heads down (AU 54, 60 out of 119 observations) were the most frequently action units displayed, replicating Study 1's results (Table 1).

### 3.2.2. Facial expression of emotion or social interaction?

Confirming Study 1's findings, there was a significant and positive relationship between Duchenne smiles' occurrences and winning a medal, as well as between Duchenne smiles' occurrences and social interaction; Pearson chi-square: for Duchenne smile and medal,  $\chi^2 (1; N = 119) = 7.60$ ,  $p = .006$ ,  $\Phi = .25$ ; for Duchenne smile and social interaction,  $\chi^2 (1; N = 119) = 9.31$ ,  $p = .002$ ,  $\Phi = .28$ .

To weight the explanatory power of emotion and social interaction in the occurrences of Duchenne smiles, we estimated a binary logistic regression model using the generalized linear model function (Hosmer & Lemeshow, 2000). First, we modeled Duchenne smiles' occurrences from a non-additive model containing two predictors (*social interaction* and *medal*) as well as their interaction. This model provided high standard errors for every variable logit estimators, not being significant the regression coefficient for the interaction of the two independent variables included in the model,  $W = .074$ ,  $p = .786$ . We found justified the removal of the interaction of *medal* and *social interaction* to model Duchenne smiles' occurrences (Table 2). Second, when analyzing the additive model, logit standard errors decreased strongly, providing more accurate estimations, and reducing the likelihood of making a Type II error. In contrast to the former non-additive model, the additive model was statistically significant,  $\chi^2 (2) = 14.93$ ,  $p = .001$ ; Hosmer–Lemeshow test  $\chi^2 (1) = 0.07$ ,  $p > .05$ . The odds of a judo fighter who is engaged in social interaction producing a Duchenne smile were 5.95 times higher than those of judo fighters not engaged in social interaction,  $W = 5.21$ ,  $p = .022$ . On the other hand, the odds of a judo fighter who is winning a medal producing a Duchenne smile were 2.58 times higher than those of judo fighters not winning a medal,  $W = 3.60$ ,  $p > .05$ . As BET would have predicted, being engaged in social interaction increases the chance of Duchenne smiles' occurrences, whereas winning a medal (i.e., feeling happiness) cannot be retained in our model as a reliable predictor in the production of Duchenne smiles (Fig. 2).

### 3.2.3. Response latency and face availability

Consistently with Study 1 findings, face availability for coding action units below a 4-s observational time frame represented 89% of judo matches. Thus, only 11% of judo matches would have included outliers that might have created an artificial overestimation of response latency's central tendency measures. Response latency for first action units being coded ( $M \pm SE = 1.81 \pm .14$ ; Andrews' Wave = 1.68) was positively skewed (skewness  $\pm SE = .50 \pm .22$ ). The expected values for response latency were below 2.5 s. Duchenne smiles' response latencies were similar to those observed for other action units ( $M \pm SE = 2.45 \pm .30$ ; Andrews' Wave = 2.40), and there was not a big impact from outliers in face availability. By observing the proportion

**Table 2**

Logistic regression model including social interaction, medal, and a non-additive model as Duchenne smile's predictors.

Duchenne Smile's Occurrences Predictors			95% CI for Odds Ratio		
Included	Excluded	B (SE)	Lower	Odds ratio	Upper
Constant		−3.24 (0.76)			
Social interaction		1.78* (0.78)	1.29	5.95	27.56
	Medal	0.95 (0.50)	0.97	2.58	6.84
	Social interaction* Medal	−0.42 (1.56)	0.03	0.66	13.94

Note. In the first step, the interaction between Social interaction and Medal was dropped from the model. In the second step, the variable Medal was dropped from the final model. Included = variables included in the final model. Excluded = variables excluded from the initial non-additive model and the second additive model. Substantive significance for modeling Duchenne smile's occurrences:  $R^2 = .184$  (Nagelkerke), .118 (Cox & Snell). Model ( $G^2$ )  $\chi^2 (2) = 14.928$ ,  $p < .001$ .

\*  $p < .05$ .

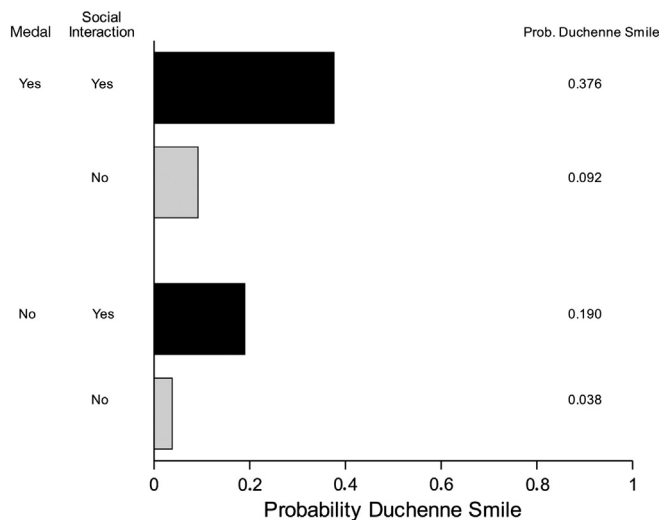


Fig. 2. Predicted probability of Duchenne smile's occurrences as a function of receiving a medal and being engaged in social interaction.

of Duchenne smiles' occurrences in Study 1 (.15) and Study 2 (.21), we can conclude that narrowing behavioral records from 7 s (Study 1) to 5 s (Study 2) did not produce any significant decrease in the proportion of Duchenne smiles' occurrences; left unilateral binomial test:  $\pi = .15$ ,  $z = 1.84$ ,  $p > .05$ .

#### 4. General discussion

Winning a gold- or bronze-medal match produced a relatively higher number of Duchenne smiles than winning a preliminary round match (7 vs. 1 in Study 1; 17 vs. 8 in Study 2). Supporters of FEP might argue that judo fighters' Study 1 emotion self-reports were less reliable predictors of Duchenne smiles' occurrences than the outcome of judo matches, concluding that winning a gold or bronze medal would be the most reliable predictor for happiness. This view would be supported by the fact that 24 out of 33 Duchenne smiles' cases were produced by judo fighters winning a medal match. However, the previous interpretation would ignore the fact that all but one of the 24 gold and bronze judo medalists displaying Duchenne smiles were interacting with others. Actually, social interaction occurred in 31 out of 33 observations in which Duchenne smiles were displayed (see Table 1). In other words, winning a medal was related to social interaction and – as it was pointed out previously – social interaction was the best predictor for smiling. Medal matches draw the attention of larger and more enthusiastic audiences, boosting the audience–sender interaction. From this “outside-in” perspective, interaction is the main predictor for smiling, and it is boosted by the quantitative (e.g., number of attendees) and qualitative (e.g., enthusiasm) features of the audience, rather than by the judo fighter's emotion.

This new finding on audience effects should not lead to a simplistic characterization of BET hypothesis. BET predicts that happiness is not a necessary or sufficient cause of Duchenne smiles. However, BET does predict that social interaction is a necessary (but not a sufficient) cause of Duchenne smiles. Some textbooks and reviews have misinterpreted Fridlund's (1994) view, concluding that facial behavior is exclusively learned or that it expresses sociality rather than emotion. Another misinterpretation of BET consists of assuming that there are universal expressions of social motives, instead of basic emotions. BET does not claim the existence of a universal expression for sociality. What BET does emphasize is that happiness does not predict smiles. A smile is just a trade-off between sender and receiver, and its meaning depends on the context in which it is produced. Such meaning – rather than expressing an inner state – is particularly relevant for producing

effects in the receiver that are beneficial for the sender. BET argues that an audience is a necessary (but not a sufficient) antecedent for facial expressions. If facial expressions are senders' behavioral tools, senders will naturally produce smiles in presence of those receivers from whom they want to get their goals. Facial expressions are not read-outs of specific basic emotions or social motives. Facial expressions are behavioral outcomes of cognitive and motivational processes that can be instantiated into multiple ways depending on the social or environmental context in which they are produced. For example, smiles are signals that can prompt cooperation and a large variety of social invitations (Mehu & Dunbar, 2008; Mehu, Grammer, & Dunbar, 2007). In turn, social invitations are frequently, but not necessarily, produced by happy senders. This fact explains the low proportion of happy judo fighters who displayed smiles (.24 in Study 1 and .35 in Study 2) as well as Duchenne smiles (.15 in Study 1 and .21 in Study 2). Whether or not they were interacting, most happy judo fighters did not display smiles at all. Although virtually all smiles were interactive, most interactions did not include smiles. Happy judo fighters' most frequent first facial movements after match completion were opened mouths and heads down (84% and 62% for Study 1; 78% and 50% for Study 2 respectively). These two action units are observed in all kinds of emotional episodes (Scherer & Ellgring, 2007). In this case, the open mouth might be related to physical exhaustion, whereas the head down could be related to cognitive or social requirements of the situation (e.g., judo fighters' habit of straightening their uniforms prior to the referee's formal awarding of the contest).

All in all, judo fighters' expressive pattern shown in Table 1 is a large mosaic of facial movements. These movements are linked to episodes that share a common emotional meaning (intense happiness) diverging in many subtle but determinant dispositional features and idiosyncratic situations. Most researchers of facial expression have fallen into a sort of confirmatory bias, focusing exclusively on the conditional probabilities of those expressions that confirmed their hypotheses. Consequently, FEP researchers ignore, as if it were “noise”, the absolute frequencies of those expressions that are unexpected (see Fernández-Dols & Ruiz-Belda, 1997).

#### 5. Conclusion

Field studies can be criticized for their lack of experimental control. We explicitly recognize such limitations. Field studies are always questionable on several points (e.g., representativeness of the indices, internal validity issues) but, as described in previous sections, our study meets all the methodological requirements summarized by Matsumoto and Willingham (2006), in the spirit of a sort of constructive adversarial collaboration.

Additionally, judo fights are not the ideal setting for testing hypotheses about the sociality of human smiles. But given the large number of publications based on Matsumoto and Willingham's (2006) study (Matsumoto & Hwang, 2012; Matsumoto, Olide, Schug, Willingham, & Callan, 2009; Matsumoto, Olide, & Willingham, 2009; Matsumoto, Willingham, & Olide, 2009) and their popularity as the ultimate answer to this question (Matsumoto, Frank, & Hwang, 2013), we decided to favor replicability for comparison purposes by keeping the behavioral setting in which Matsumoto and Willingham based their dismissal of the BET hypothesis.

The main goal of the reported studies was to weigh the predictive power of emotion and social interaction as antecedents of smiles, and particularly Duchenne smiles. Social interaction was the strongest predictor for Duchenne smiles, whereas happiness was not retained in our model as a predictor for smiling. Likewise, there were no significant differences between the emotions reported by smiling and non-smiling judo fighters (Study 1). These findings provide strong empirical support for BET on the sociality of human smiles (Fridlund, 1994; Parkinson, 2005). A second important empirical finding concerns the latency between the antecedent and the full unfolding of Duchenne smiles.



Matsumoto and Willingham (2006) claimed that Duchenne smiles need a minimum of 4 s to fully unfold, but our data show that most Duchenne smiles (88% in Study 1 and 96% in Study 2) were displayed within a shorter period of time (with average unfolding times of 2 s). All in all, our findings support Kraut and Johnston's (1979), Fernández-Dols and Ruiz-Belda's (1995), and Ruiz-Belda et al.'s (2003) results, providing evidence for BET rather than FEP, and qualifying Matsumoto and Willingham's (2006) findings on the presence of Duchenne smiles in winning judo fighters.

We would like to forestall some potential misunderstandings on the conclusions of this article. First, we do not deny the universality of human smiles; there are no records of healthy human beings physically unable to smile. Our point is that smiles are primarily a social behavior, a key component of some adaptive strategies, but not a fixed adaptation, a universal readout of an ancestral happiness.

Second, we have never denied, despite Matsumoto and Willingham's (2006) claims, that Duchenne smiles (as well as other expressions) cannot be observed in natural situations. Our study is an empirical test of which theory predicts these smiles in a winning judo fighter. In their study, Matsumoto and Willingham concluded that 86% of the judo fighters displayed universal expressions of emotion at match completion (p. 576) and that the most representative facial expression of all winners was a Duchenne smile because Duchenne smiles were probably "the only facial marker" (p. 577) of enjoyment. We have empirically addressed Matsumoto and Willingham's conclusion through a more refined test, which takes into account the methodological requirements pointed out by Matsumoto and Willingham themselves. And our data supported that social interaction is the predictor of Duchenne smiles.

Finally, our hypothesis and findings are not, for obvious reasons, denying the evolutionary basis of smiles and other facial expressions. Most psychologists have taken for granted that the only feasible evolutionary assumption about smiles is that they are adaptations, expressions of an ancestral happiness. But the BET approach to facial expressions, while excluding that the evolutionary function of smiles is to express happiness, emphasizes the adaptive role of smiles and it is sustained on a sound evolutionary approach to human behavior (Fridlund, 1994).

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